

Support Worksheet – Topic 2, Worksheet 5

- 1** Two probes are in orbit around a planet of mass M and radius R . Probe 1 has an orbit radius r and probe 2 an orbit radius $2r$. Calculate the ratios:
- a** $\frac{F_1}{F_2}$ (where F is the force on a probe from the planet) [1]
- b** $\frac{E_1}{E_2}$ (where E is the total energy of a probe). [1]
- 2** A probe of mass m is to be lifted (very slowly) from the surface of a planet of mass M and radius R to a height $h = R$ above the surface. Derive an expression for the work that must be done on the probe. [2]
- 3** A probe is in orbit around a planet of mass M and radius R . The radius of the orbit is $r = 2R$. Calculate the work that must be done on the probe in order to move it into a new circular orbit of radius $r = 3R$. [2]
- 4** **a** A probe of mass m is released from rest from a height $h = R$ above the surface of a planet of mass M and radius R . The planet has no atmosphere. Show that the speed with which the probe impacts the planet's surface is $v = \sqrt{\frac{GM}{R}}$. [2]
- b** Evaluate this speed for Mars for which $M = 6.4 \times 10^{23}$ kg, $R = 3.4 \times 10^6$ m. [1]
- c** State and explain whether the actual speed for such a probe will be less than or greater than your answer in **b**. [1]
- 5** **a** Show that the escape speed from the surface of a planet of mass M and radius R is given by $v_{esc} = \sqrt{\frac{2GM}{R}}$. [2]
- b** Calculate the escape speed from Earth ($M = 6.0 \times 10^{24}$ kg, $R = 6.4 \times 10^6$ m). [1]
- c** Voyager 2, a spacecraft launched in the late 1970s has left the solar system by now and for all practical purposes has escaped the gravitational influence of the Earth, the Sun and the other planets. The launch speed of Voyager was considerably less than the escape speed calculated in **b**. Explain this observation. [1]
- 6** A probe of mass m is launched from the surface of a planet of mass M and radius R with a speed that is half the escape speed. Calculate, in terms of R , the maximum distance from the planet the probe will get to. [3]